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(71) Applicant 00002255

Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(72) Inventor: C. Fukada

c/o Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(72) Inventor: I. Sakurai

c/o Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(72) Inventor: M. Kato

c/o Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(72) Inventor: H. Watanabe

c/o Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(72) Inventor: Y. Morishita

c/o Showa Electric Wire Cable K K

1-1, 2-Chome, Odasakae, Kawasaki-ku,

Kawasaki City, Kanagawa-ken

(74) Agent, Attorney: S. Sato and one other person

(54) [Subject of Invention]

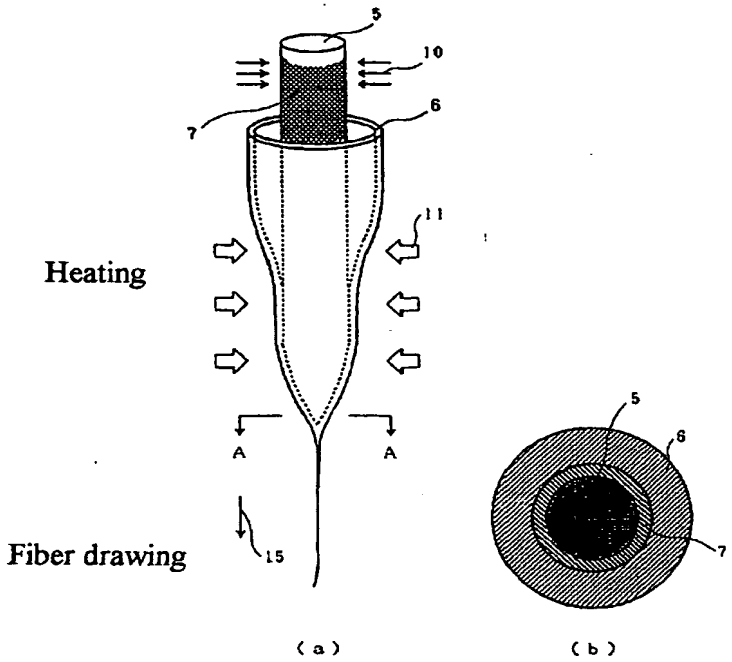
Manufacturing method of optical fiber

(57) [Summary]

[Objective] By adapting the so called rod in tube method to form a hermetic layer in the boundary of the core portion and the clad portion.

[Constitution] To the outer circumference of the preform rod 5 forming the core portion and/or the inner circumference face , the hermetic layer 7 of single layer or multi-layers is formed beforehand by the vapor deposition and/or the sputtering, etc. methods. This hermetic layer 7 is composed of carbon and/or gold layer. Based on the rod in tube method, the hermetic layer 7 can be formed to a certain thickness between the preform rod 5 and the tube 6 to carry out the spinning (fiber drawing). For the hermetic layer 7, in addition to the above, it can be formed by reduction treatment of oxide or halide of metal; or a molten metal can be adhered.

5...preform rod
6...tube
7...hermetic layer



[Scope the Patent Claim]

[Claim Item 1] An optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad,

to the outer circumference surface of the aforementioned preform rod or to the inner circumference surface of the aforementioned tube or to both of the surfaces, a hermetic layer by the vapor deposition is formed, and

the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[Claim Item 2] An optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad,

to the outer circumference surface of the aforementioned preform rod or to the inner circumference surface of the aforementioned tube or to both of the surfaces, oxide or halide of metal is adhered in layer shape and by reduction treatment, a hermetic layer based on metal is formed, and

the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[Claim Item 3] An optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad,

to the space between the outer circumference surface of the aforementioned preform rod and the inner circumference surface of the aforementioned tube, a molten metal is filled to form a hermetic layer based on this metal, and

the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[Claim Item 4] An optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad,

to the space between the outer circumference surface of the aforementioned preform rod and the inner circumference surface of the aforementioned tube, wire (fiber) shape metals are sandwiched to form a hermetic layer based on this metal, and

the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[Detailed Explanation of the Invention] [0001] [Industrial Application Field] The present invention is related to an optical fiber manufacturing method for producing an optical fiber in a construction which prevents the invasion of hydrogen and/or water into the fiber.

[0002] [Conventional Technology] Optical fibers are widely applied to the fields of communication and information transmission. This optical fiber possesses a core portion and the clad portion to seal the optical signals in the core portion to carry out transmission. When this kind of optical fiber is used for a long period of time, from the outside, hydrogen and/or water would invade into the core to cause a problem of so called performance degradation. Namely, the thin glass layer constructing the optical fiber cannot completely shield the invasion of the hydrogen and/or water; and by these invasions, the signals being transmitted in the core portion of the optical fiber would be

scattered or absorbed to cause attenuation. Accordingly, so far, the protection methods based on covering the outer circumference of the optical fiber by a material which would not allow the permeation of hydrogen and water have been developed. For this protection layer, carbon layer ,etc. can be listed.

[0003] However, after this kind of protective layer is formed, for further mechanical protection, if various plastics are coated, there have been cases that the protective layer and the plastic would adversely affect each other. And during the splicing, etc. operation, if the plastic coat is removed, the protective layer has to be peeled off simultaneously; thus, a problem would be that a treatment of protective layer formation has to be performed again. For solving this problem, the method for forming a protective layer between the core portion and the clad portion has been described in, for example, Patent Disclosure Bulletin No. 60-249109 (1985).

[0004]

[The Problem to be Solved by the Invention] However, it is not easy to form the hermetic layer described above in a suitable thickness at the boundary of the core portion and the clad portion. The present invention is aimed at this point; the objective is to provide an optical fiber manufacturing method for nicely forming a hermetic layer at the boundary of the core portion and the clad portion by adapting the rod in tube method.

[0005]

[The Means Used Solve the Problem] The No. 1 invention is related to an optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad, to the outer circumference surface of the

aforementioned preform rod or to the inner circumference surface of the aforementioned tube or to both of the surfaces, a hermetic layer by the vapor deposition is formed, and the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[0006] The No. 2 invention is related to an optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad, to the outer circumference surface of the aforementioned preform rod or to the inner circumference surface of the aforementioned tube or to both of the surfaces, oxide or halide of metal is adhered in layer shape and by reduction treatment, a hermetic layer based on metal is formed, and the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[0007] The No. 3 invention is related to an optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the clad, to the space between the outer circumference surface of the aforementioned preform rod and the inner circumference surface of the aforementioned tube, a molten metal is filled to form a hermetic layer based on this metal, and the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[0008] The No. 4 invention is related to an optical fiber manufacturing method having the following characteristics: In the case in that an optical fiber is manufactured by covering the outer circumference of the preform rod containing the core portion with a tube for the

clad, to the space between the outer circumference surface of the aforementioned preform rod and the inner circumference surface of the aforementioned tube, wire (fiber) shape metals are sandwiched to form a hermetic layer based on this metal, and the aforementioned tube is tightly adhered to the outer circumference of aforementioned preform rod to carry out fiber spinning (drawing).

[0009]

[Function] To the outer circumference of the preform rod forming the core portion and/or the inner circumference face , hermetic layer of single layer or multi-layers is formed beforehand by the vapor deposition and/or the sputtering, etc. methods. This hermetic layer is composed of carbon and/or gold layer. Based on the rod in tube method, the hermetic layer can be formed to a certain thickness between the preform rod and the tube; then the spinning (fiber drawing) is carried out. For the hermetic layer, in addition to the above, it can be formed by reduction treatment of oxide or halide of metal; or a molten metal can be adhered.

[0010]

[Implementation Example] Below, the present invention is illustrated in details by using implementation examples. Fig 1 shows an implementation example of the optical fiber manufacturing method of the present invention: (a) is an oblique view of the preform rod and the tube during the manufacturing and (b) is e the cross section of the line along A—A of (a). In the figures, the optical manufacturing method based on the well known rod in tube method is utilized. Namely, the preform rod 5 is a glass rod possessing a fixed refractive index of the core portion of the optical fiber (to the outer circumference a clad portion has been provided: cf 10). The outer circumference of this preform rod 5 would

be covered by the tube 6 composed of glass for the clad. Under this condition, when the portion indicated by the arrows is heated, the tube 6 would be softened and tightly adhered to the preform rod 5. And, when the bottom-end is pulled to draw fiber in the direction indicated by the arrow 15 in the figure, a certain diameter of optical fiber would be obtained.

[0011] Here, in the present invention, to the outer circumference surface of the preform rod 5, at the position indicated by the arrows 10, a hermetic layer by vapor deposition is to be formed. For the material of this hermetic layer, carbon, etc. are suitable. In some cases for more than a certain thickness of this hermetic layer 7 would be required; and by just one vapor deposition operation, the required thickness cannot be obtained. Therefore, the vapor deposition is divided into a number of times to complete the suitable thickness. For the formation of carbon layer, for example, the method based on the adhesion of thermal decomposed hydrocarbon gas can be employed. And the sputtering method and CVD method, etc. can also be used.

[0012] And, the hermetic layer is formed either onto the outer circumference surface of the preform rod 5 or onto the inner circumference surface of the tube 6. And by forming the hermetic layer to both surfaces, an even thicker hermetic layer can be provided at once. By manufacturing the optical fiber through the above, as shown in Fig 1 (b), when it is viewed from the A—A cross section of (a), it would become the state that to the outer circumference of the preform rod 5, the tube 6 would be tightly adhered through the hermetic layer 7; by fiber spinning (drawing) of this, the specified construction of optical fiber can be obtained.

[0013] Furthermore, the formation of the hermetic layer can also be based on the methods such as the VAD soot synthesis method, etc. And, for the metal to be used for vapor deposition, tin, etc. are suitable. In the arrangement of the hermetic layer, it can be provided at any position of the clad as long as it is within the range where the light can be sufficiently propagated.

[0014] When the aforementioned hermetic layer is to be formed in relatively large thickness, instead of a carbon, a metal layer would be easier. In the case where a metal layer is to be formed, for example, by the vapor deposition or sputtering, etc., under the condition shown in Fig 1, a metal oxide or halide is adhered to the outer circumference surface of the preform rod 5. After this, before the initiation of the fiber drawing or during the fiber drawing, the preform rod 5 and the tube 6 are placed in an inert gas and/or hydrogen gas to reduce the metal oxide or halide. By this, a metal layer would be formed in the space between the preform rod 5 and the tube 6. When this is drawn, an optical fiber of the construction similar to the previously illustrated can be manufactured. Further, as a method of forming the metal layer, in addition to the aforementioned, the sol-gel method can also be employed.

[0015] In Fig 3, another method of forming metal layer is shown. This figure is the cross section of the tube arranged to the outer circumference of preform rod. As shown in the figure, the tube 6 forming the clad portion winding around the preform rod 5 is arranged. The method of this arrangement is entirely identical to the implementation example shown in Fig 1. Here, in the space between the preform rod 5 and the tube 6, tin, etc. molten metal 12 is filled. Under this condition, while the oxidation of the metal is being

prevented, the fiber drawing is performed, the optical fiber of the cross section structure as shown in Fig 1 (b) would be obtained.

[0016] Furthermore, when the metal coating is performed as described above, the construction of the preform 5 is desirable that the construction of the preform rod 5 is that a specified thickness clad portion against the core portion is coated beforehand. The thickness of the clad portion forming the preform 5 is desirably to be the level that the light leaking out the core portion would become sufficiently weak. For example, in the case the core diameter is 10 micrometer (um), if the wavelength of the transmission light is 1.3 um, the thickness of the clad portion forming the preform rod is preferably to be more than 5 um. The metal layer, in this case, if it is more than 0.1 um, the role of shielding the specific hydrogen and/or water can be achieved. Furthermore, if it is more than 5 um, breakage could occur by its thermal expansion difference with the surrounding glass of the tube 6 constructing the clad portion. Further, to the outer circumference of the metal layer, a glass layer of 50 to 100 um level is to be formed.

[0017] And, the molten metal 12 of the implementation example shown in Fig 3 can be poured into the space between the preform rod 5 and the tube 6 beforehand (the metal under molten state) or it can be in the constitution that the metal can be delivered in powder shape and the bottom portion is to be melted by the fiber drawing heat. Furthermore, in the case where the aforementioned metal layer is made to be the hermetic layer, it would become possible that that a current be flowed here (the metal layer). Therefore, by utilizing this hermetic layer, a certain signals and/or electric power can be transmitted.

[0018] Fig 4 further shows other implementation example of the optical fiber manufacturing method of the present invention; (a) is the cross section of the preform rod and (underline portion added by the translator) the tube covering the preform; and (b) is the cross section of the line along B—B of (a). As shown in Fig 4 (a), in this implementation example, suitable pieces of the metal wire 13 are inserted into the space between the preform rod 5 and the tube 6. When the fiber drawing is performed under this condition, as shown in (b), it can be made to the construction that the metal wire 13 is sandwiched between the preform rod 5 and the tube 6. Further, when this metal wire 13 is partially melted by the heating, as shown in the figure, the hermetic layer 14 based on the metal would be formed simultaneously in between the preform rod 5 and the tube 6. By this, the hermetic layer forming is carried out and at the same time the metal wire 13 capable of conducting a certain level of current can be arranged inside the fiber.

[0019] The present invention is not limited to the above implementation examples. The construction of the preform rod in the aforementioned implementation examples can be a kind in that more than one layer of clad portion is formed to the outer circumference of the core portion. And, its refractive index distribution can be the so called step-index or the graded-index. The tube can also be a multi-layer structure for constructing the clad portion. And, the glass material can be a quartz glass or a multi-component glass.

[0020]

[Effect of the Invention] According to the above described optical fiber manufacturing method of the present invention, by the rod in tube method, a hermetic layer is formed in the space between the preform rod and the tube for the clad; therefore, there is no need to achieve matching with the plastic layer, etc. to be used to cover the outside; and since the

hermetic layer is protected mechanically, the performance would be stable. Furthermore, by the rod in tube method, this kind of optical fiber can be mass-produced continuously.

[0021] And, by the approach in that to the outer circumference surface of the aforementioned preform rod or to the inner circumference surface of the aforementioned tube or to both of the surfaces, metal oxide or metal halide is adhered in layer shape and the oxide or the halide is then reduced, a homogeneous hermetic layer based on the metal free from impurity can be formed. And, by filling the space between the outer circumference surface of the preform rod and the inner circumference surface of the clad with a molten metal to form the hermetic layer, a relatively thick hermetic layer can be easily formed. Furthermore, by sandwiching metal wire(s) between the preform rod and the tube to form the hermetic layer, electrical current can be also flowed through this electric wire. By the above described methods, the thickness of the hermetic layer can be relatively easily and freely controlled; optical fibers possessing high quality in hydrogen durability, water durability can be manufactured.

[Brief Explanation of Figures}

Fig 1 shows an implementation example of the optical fiber manufacturing method of the present invention: (a) is an oblique view of the preform rod and the tube during the manufacturing and (b) is e the cross section of the line along A—A of (a).

Fig 2 is the cross section of an optical fiber possessing the hitherto known hermetic layer.

Fig 3 is the cross section of the preform rod and the tube in that the hermetic layer is formed by a molten metal based on the present invention.

Fig 4 further shows other method of the present invention: (a) is the cross section of the preform rod and the tube; and (b) is the cross section of the line along B—B of (a).

[Illustration of Symbols]

5...preform rod

6...tube

7...hermetic layer

Fig 1

5...preform rod
6...tube
7...hermetic layer

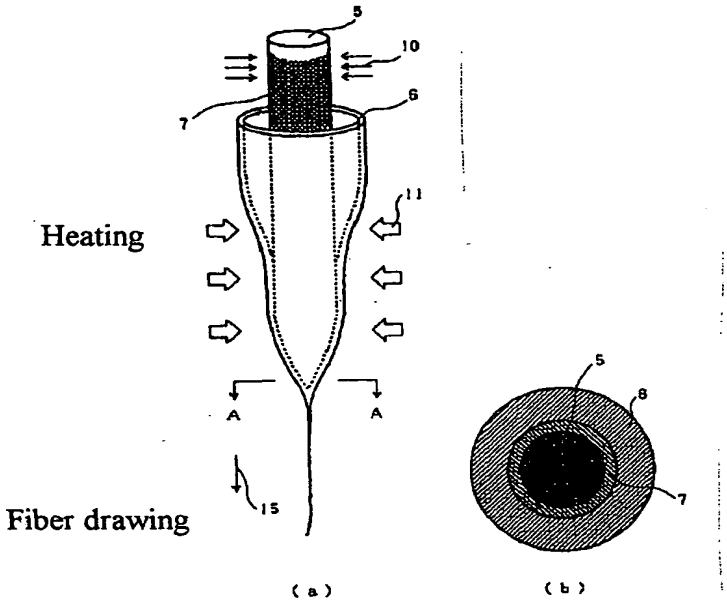


Fig 2

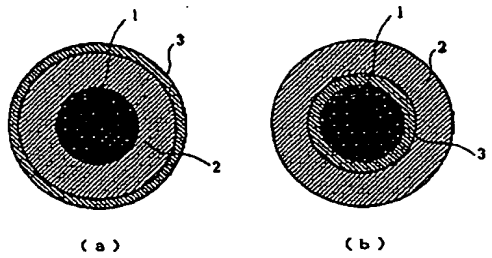


Fig 3

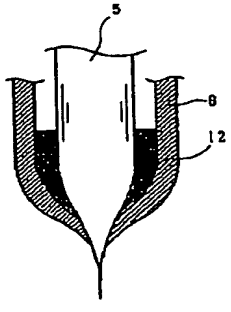


Fig 4